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TOMATO KETCHUP UNDER THE MICROSCOPE;
WITH PRACTICAL SUGGESTIONS TO INSURE A CLEANLY PRODUCT.

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INTRODUCTION.

The various products manufactured from tomatoes are becoming more and more important commercially from year to year. Those who have watched the industry during the past 5 or 10 years have noted radical changes in some of the manufacturing methods which tend to produce a cleaner and more wholesome product. Especially is this true of the manufacture of ketchup. Some manufacturers, however, are still producing their product under conditions which show a lamentable lack of care, and are making themselves liable to prosecution and their products to condemnation. It is, however, the writer's opinion that much of this is the result of ignorance as to the influence that certain methods of handling exert upon the character of the product. It is for the purpose of giving the manufacturer the benefit of certain practical results of laboratory and factory investigations of the various methods of handling these products that this circular is written. It is not intended to deal with the subject exhaustively, nor to present the detailed micro-analytical data on which the conclusions are based, but rather to give the practical deductions of the investigations and the reasons for the same in a manner that will be clear to the manufacturer, who may not have a technical education. To this end some points which may be used to advantage by those engaged in the manufacture of such products will be emphasized and some of the pitfalls which beset the manufacturer indicated.

NATURE OF DECAY.

Under the food and drugs act, June 30, 1906, a food product is deemed to be adulterated "if it consist in whole or in part of a

filthy, decomposed, or putrid animal or vegetable substance." Decay or putrefaction in tomatoes is commonly the result of the attacks made by various forms of plant life upon the fruit or upon the partially manufactured product. Among these, yeasts, bacteria, and molds of various species are the most common. They feed upon certain compounds in the tomato, reducing the food value of the product, producing by-products of a more or less offensive character, and usually modifying the characteristic flavor of the product. They may attack the fruit on the vine before picking or at almost any of the various steps of manufacture, and if the conditions for preservation are not right they may infect and cause spoilage in the finished product. Among the forms most liable to attack the fruit on the vines are some species of molds. One of the most familiar molds, both to the farmer and to the manufacturer, results in the production of "dry" or "black rot." Some others appear as white growths on the fruits and usually develop after the fruit has been taken from the vines, entering through cracks or fissures in the skin of the fruit. This also occurs in the entrance and growth of yeasts and bacteria. If the temperature conditions are favorable the development of yeast and bacteria in the raw flesh of the tomato or in the raw partially manufactured product is very rapid and the rate of growth increases tremendously when the hosts are stored in close, warm quarters. Good ventilation tends on the other hand to retard such growth. The decomposition products due to these organisms appear to be much the same whether the growth occurs on the whole fruit, in the pulp, or in the stored product. Boiling may arrest the growth for a few hours, but if the product is not shielded from fresh infection, the benefit thus derived is only temporary, for it is the common knowledge of many manufacturers that tomato pulp will keep only a short time, even after prolonged heating, unless it is stored in well-sealed packages of some sort. It is at this point that some manufacturers have failed because, although the raw materials may have been fairly free from decayed or putrid material, they have handled it in such a way as to allow decomposition to occur at some of the various stages of manufacture. As a general rule it seems that the decay for which molds are largely responsible appears in the fruit before the actual manufacturing processes are begun, that is on the vines, or in the crates after picking, while those forms in which yeasts and bacteria play the principal rôle appear in greatest numbers at some stage after the manufacture has begun. Therefore it is seen that a product may be subject to criticism when the trouble is almost wholly due to molds present on the raw fruit. This is particularly true of much of the product made up at once during the packing season from trimming materials which have not been stored for a sufficient length of time for other forms of decomposition

to occur. In some other cases the spoilage is due principally to yeasts, and again bacteria may be the chief source of trouble. Then again any two or all three forms of organisms may be present.

Some manufacturers have supposed that the boiling incident to manufacturing ketchup removed these organisms and the products of decomposition from the material. But this is far from true; for although they may be killed so that further spoilage due to them will not occur, the forms are still readily seen by the aid of the compound microscope, and by chemical methods it has been shown that some of the most important products of the decay remain and the food value of the product is irreparably injured.

METHODS OF MICRO-ANALYSIS AND INTERPRETATION OF RESULTS.

The methods used for determining the character of a pulp or ketchup are given, since inquiries are repeatedly received for this information. Unfortunately they are of such a character that the manufacturer without scientific training can not use them to any great extent, though with practice a layman might be able to judge roughly in some particulars as to the character of the product.

APPARATUS REQUIRED.

The outfit used is as follows:

A good compound microscope giving magnifications of approximately 90, 180, and 500 diameters. This is accomplished by the use of a 16 mm (two-thirds of an inch) objective and an 8 mm (one-third of an inch) objective, together with a medium (×6 compensating) and also a high-power ocular (×18 compensating). A Thoma-Zeiss blood-counting cell,[1] a 50 cc graduated cylinder, and ordinary slides and cover glasses complete the apparatus required. It is impractical to use objectives of a higher power than those mentioned, because of their short working distance, which makes their use with the counting cell impossible.

ESTIMATION OF MOLDS.

A drop of the product to be examined is placed on a microscope slide and a cover glass is placed over it and pressed down till a film of the product about 0.1 mm thick is obtained. After some experience this can be done fairly well. A film much thicker than this is too dense to be examined successfully, while a much thinner film necessitates

[1] This is a cell named after the designer of the form of rulings used, and consists of a slide with a disk ruled in one-twentieth mm squares, so arranged that when the cover is in place the film of liquid under examination is one-tenth mm deep. They were originally intended for counting corpuscles in the blood and are obtainable from practically all manufacturers of microscopic accessories.

pressing the liquids out, which gives a very uneven appearing preparation. When a satisfactory mount has been obtained, it is placed under the microscope and examined. The power used is about 90 diameters, and such that the area of substance actually examined in each field of view is approximately 1.5 sq. mm.

A field is examined for the presence or absence of mold filaments, the result noted, and the slide moved so as to bring an entirely new field into view. This is repeated till approximately 50 fields have been examined, and the percentage of fields showing molds present are then calculated. Our experience has demonstrated that for homemade ketchups this is practically zero, and with some manufactured ketchup it is as low as from 2 to 5 per cent, while for carelessly made products it may be 100 per cent; that is, every field would show the presence of mold. Investigations under factory conditions clearly indicate that with only reasonable care the proportion of fields having molds can be kept below 25 per cent. A specimen in which 60 per cent of the fields have molds is in more than twice as bad a condition as one containing 30 per cent.

After the percentage reaches 30 to 40 per cent it will be found that some of the fields frequently have more than one filament or clump of mold, and the number of such fragments might be counted, but in this laboratory this usually is not done. A Thoma-Zeiss counting cell with a center disk of 0.75 inch instead of 0.25 inch, as usually furnished, would give a regular depth of liquid and would be more exact than the method described, but this must be specially manufactured, not being listed in any of the catalogues of microscopic supplies, and the method as given is sufficiently accurate for the purpose. When the number of fragments of mold per cubic centimeter is estimated, it has been found to range from virtually zero to over 20,000. There is no excuse for a manufacturer allowing such conditions to prevail that his ketchup shows more than 2,000 per cubic centimeter, while some manufacturers by careful handling hold it down to 150.

ESTIMATION OF YEASTS AND SPORES.

Though the spores referred to are those coming from molds and correspond to seeds in more highly developed plants, it is frequently very difficult to differentiate some of them with certainty from some yeasts without making cultures, which is obviously impossible in a product that has been sterilized by heat. For this reason the yeasts and spores have been reported together, and if there seemed to be a larger percentage of the latter, mention was made of that fact.

To make a count 10 cc of the product is thoroughly mixed with 20 cc of water, and after being allowed to rest for a moment to permit the very coarsest particles to settle out, a small drop is placed on the central disk of the Thoma-Zeiss counting cell and then covered with

a glass. Care must be exercised to have the slide perfectly clean, so that, when the cover glass is put in place, a series of Newton's rings[1] results from the perfect contact of the glass surfaces; and, furthermore, the drop should be of such size as not to overrun the moat around the central disk and creep in underneath the cover glass, thus interfering with the contact.

With the magnification of 180, it has been the practice in this laboratory to count the number of yeasts and spores on one-half of the ruled squares on the disk. With the dilution used this calculates back to a volume equal to one-sixtieth of a cubic millimeter in the original sample, and reports are made on that basis rather than on the number in a cubic centimeter, because the former number is more readily grasped by the mind and affords a simpler notation. To obtain the numbers per cubic centimeter the count made is simply multiplied by 60,000.

It has been found in practice that the number of yeasts and spores varies, for one-sixtieth of a cubic millimeter, from practically none in homemade and first-class commercial ketchups up to 100 or 200, and in one sample the number was as high as 1,200. Laboratory experiments show that, when the number of yeasts in raw pulp reaches from 30 to 35 in one-sixtieth of a cubic millimeter the spoilage may frequently be detectable by an expert by odor or taste, and from experiments made under proper factory conditions, it seems perfectly feasible to keep the number in commercial ketchups below 25.

ESTIMATION OF BACTERIA.

The bacteria are estimated from the same mounted sample as that used for the yeasts and spores. A power of about 500, obtained by using a high-power ocular, is employed in this case, and because of the greater number present a smaller area is counted over. Usually the number in several areas, each consisting of five of the small-sized squares, is counted and the number of organisms per cubic centimeter is calculated by multiplying the average number in these areas by 2,400,000. Thus far it has proved impracticable to count the micrococci present, as they are likely to be confused with other bodies frequently present in such products, such as particles of clay, etc. A comparison of this method with the ordinary cultural methods on samples in which the organisms had not been killed has almost invariably shown that the one used gives too low instead of too high results. In some cases it was found to give not more than one-third of the entire number present. The estimates of the laboratory on this point may, therefore, be considered very conservative.

[1] These are rainbow-colored rings produced at the point of contact when polished plates of glass are pressed against each other.

As regards the limits which may be expected in the examination of ketchups for bacteria, it might be stated that some manufactured samples as well as good, clean products made by household methods, have been examined and the count found to be so low when estimated by this method that the numbers present were reported as negligible. In other words, it was found that for the areas counted over the number of bacteria averaged less than one—that is, less than 2,400,000 per cubic centimeter. It is unusual, however, for the final number per cubic centimeter to be less than from 2,000,000 to 10,000,000 organisms. Contrasted with this number as a minimum, it has been found that the number has occasionally exceeded 300,000,000 per cubic centimeter. Such a number as this would indicate extremely bad conditions and carelessness in handling, as the studies of factory conditions has shown that there is little excuse for the number ever exceeding 25,000,000 per cubic centimeter. While experiments have also shown that although the effect produced by the bacteria on the product varies with different species, it is true that their presence can frequently be detected in the raw pulp by odor or taste when the number exceeds 25,000,000 per cubic centimeter and sometimes when the count is as low as 10,000,000.

To one who has not been initiated into the mysteries of the microscope the presence of such a number of bacteria in a food product seems inexcusable. It must be remembered in this connection that the most of these are probably nonpathogenic forms, and many occur naturally on the skins of the fruits. It does not seem just to set a standard so high as to virtually prohibit the manufacture of the product under commercial conditions; rather the idea is to set a limit that the manufacturer can attain if due care is exercised and which will insure a cleanly product. It is, however, perfectly possible to make a cleanly, wholesome product commercially even though the number of bacteria exceed that in the homemade article.

The allowable limits for the bacterial content of tomato pulp vary according to the concentration. The number, however, should be low enough so that when the amount of concentrating necessary for its conversion into ketchup has been accomplished the final product will still be within permissible limits (25,000,000 per cubic centimeter). Thus for a pulp which must be concentrated one-half the bacterial counts should not exceed about half the limits stated above for the ketchup itself—i. e., it should not be more than 12,500,000 per cubic centimeter. The same general rule should also apply to the content of molds and of yeasts.

To insure a sound product, free from decay or any filthy material, many factors must be carefully watched, for not infrequently oversight in one particular has been found to have undone the good effects

of the care exercised in all other ways. Thus it is possible for the washing of the fruit to be ideal and the sorting out or removing of the decayed portions beyond criticism, and yet a delay in making up the pulp into the final product may allow an amount of decomposition to occur which offsets the care previously exercised. It has been a matter of surprise to some manufacturers to find with what rapidity some of these organisms increase. In one factory where this point was tested, the bacterial content in a batch of tomato trimming juice was found to be about 7,000,000 per cubic centimeter when taken from the peeling tables, and after standing at room temperature for five hours it had increased to 84,000,000. This was a twelvefold increase in a length of time which was less than half the working day for some of the factories visited. At the end of five days the number had increased to nearly 3,000,000,000 per cubic centimeter. Thus it is seen that delay in manufacture is very liable to result disastrously.

Such facts as these serve to emphasize the great importance of absolute cleanliness in every detail about factories of this kind. Dirty floors and ceilings and apparatus left with residues of tomato product clinging to them are most fruitful sources for the contamination of new batches of the product. To clean such an establishment properly it is almost imperative that machinery and woodwork be washed by means of live steam used lavishly at frequent intervals. To leave buckets, tables, conveyors, or any other part of the equipment or floors overnight without cleansing them, as was the practice in some factories, is reprehensible and tends to contaminate the product and lead to spoilage and loss.

GENERAL CONDITION OF THE FRUIT.

Certain points concerning the general character of the fruit received and accepted at different factories have an intimate bearing on this investigation.

In some places the fruit is demanded in such a dead ripe condition, because of the brighter color imparted to the final product, that there is usually a large amount broken and crushed during transportation and more liability of the development of decay-producing organisms. Such fruit requires more labor in sorting and a larger proportion of waste must result. Because of the extra labor involved in properly removing the decayed portions it is frequently only partially accomplished, and the final effect on the quality of the product is to sacrifice cleanliness to color. There is, of course, no objection to the color itself, but only to the danger attending the use of such ripe fruit that a larger amount is in a more or less advanced state of decay and its removal is only partially accomplished.

METHODS OF HANDLING.

For convenience of discussion the influence of different methods of handling is discussed under the following heads, though the order in which they are actually conducted in various factories varies quite widely: (*a*) Sorting, (*b*) washing, (*c*) pulping, (*d*) concentrating, (*e*) storing.

SORTING.

From a study of various methods followed in different factories it seems that at present there is no purely mechanical method of sorting that is satisfactory for performing this work. Especially is this true of the removal of the so-called "dry rot" or "black rot." Some manufacturers have very erroneously supposed that because of the rather hard texture of the dry rot none of it went into the pulp while passing through the cyclone. This is entirely contrary to the facts in the case, as the action of the machine removes most of the dry rot from the fruit and passes it out with the rest of the pulp in which it is easily detected and injures the appearance and character of the final product. In one washer examined the soft rot was satisfactorily removed mechanically, and this apparatus, which was a "home device," will be described under "Washing."

In some factories where the tomatoes are peeled and either canned or made into some whole-tomato product such as chili sauce, the trimmings are used in the manufacture of pulp or ketchup. Some manufacturers make no attempt to reject the decayed portions of the fruit and hence their products are almost sure to show up badly under the microscope. On the other hand, some firms depend on the peelers to sort out and reject the decayed portions, but after watching this as practiced in different places, the writer is convinced that the elimination of objectionable parts can not be effectively accomplished in regular factory practice by this method, for, being paid by the piece for the peeled tomotoes only, the peelers become careless or indifferent about the removal of the decayed portions from the trimmings which are to be used for pulp making. In one place where this method was followed, an examination of portions of the trimmings collected during the day showed from 15 to 20 per cent of the fragments to be decayed to a considerable degree. In some factories the sorting is done before the washing or scalding, others make it an intermediate operation between the principal washing and the scalding with a final rinsing. Then the peelers are furnished with buckets in which to place any decayed parts that they may find which escaped the principal sorting. In favor of the intermediate method there is this to be said, that the fruit being more or less washed, the decayed portions are more readily seen and picked out.

Some manufacturers have asked what would be the influence of using tomatoes which are partially decayed, provided the decayed portions were cut out. It has been shown by experiments made under factory conditions that if the decayed portions are carefully cut out and discarded the remaining peeled portions of tomatoes may be almost as free from objectionable material as a product made from wholly sound tomatoes. An experiment illustrating this fact was made in one factory with the results given in the table. The fruit was carefully sorted into three grades before washing. Grade No. 1 contained mostly sound tomatoes, but due to the overripe condition of the fruit more decayed spots went in than would usually be the case. Grade No. 2 represents those tomatoes which were partially decayed, and No. 3 those which were so badly decayed as to be wholly worthless and which were entirely discarded. The chili sauce from these gave the following results:

Chili sauce from sound and from partially decayed tomatoes, using only the sound portions.

Kind of organisms.	Grade No. 1. Sound tomatoes.	Grade No. 2, made from tomatoes from which the decay was removed.
Yeast and spores per one-sixtieth cu. mm.	4	6
Bacteria per cubic centimeter	2,000,000	9,000,000
Molds	(1)	(2)

1 Less than 2 per cent. 2 Less than 2.5 per cent.

While the number of bacteria in the second-grade product appears to be much higher than in the first-grade, this difference is almost negligible when considered in connection with the allowable limit of 25,000,000. Pulp made from trimmings of grade No. 1, which had been allowed to stand on an average about one and one-half hours, gave:

Yeasts and spores per one-sixtieth cu. mm	13
Bacteria per cc	9,000,000

Molds in 17 per cent of fields.

From the first grade there were obtained four barrels of peeled tomatoes and two barrels of trimmings; from the second grade one barrel of peeled tomatoes and two barrels of trimmings. From this it is seen that the condition of the fruit was such as to make the loss due to decay very heavy.

At some factories they sort by pouring the fruit from the crates upon tables placed conveniently to the washing apparatus, and the fruit is looked over and decayed pieces removed before it is dumped into the washer. In other places the fruit from the washer is dropped

upon some form of conveyor, which carries it alongside of the persons doing the sorting, who are supposed to examine and remove all undesirable fruit. At another place the sorting was done by picking the fruit by hand out of the crates and making the examination. Of these three methods the last may be somewhat the best, but is expensive, because of the time required in the handling of the product. After working beside the sorters, noting each method, and observing carefully the results obtained, it appeared to the writer that a large part of the defective sorting was due to the fact that in order to make sure that every fruit is sound it must be turned over in some way so that all sides of it may be inspected, and thus far no mechanical device for doing this has been seen. If this could be accomplished, it would result in a great saving of time in those factories where the sorting is at present being well done, and in a more effective sorting in those places where at present too few persons are assigned to this inspection to make it satisfactorily when so great a quantity of tomatoes must be examined in a short time. It seems that it would not be a serious mechanical problem to devise an apparatus which would turn the tomatoes as they pass in front of the sorters, and thus increase the effectiveness of this part of the work.

WASHING.

The process of washing is a very important one, since by it the sand and soil are removed, and if this is not properly done, the product is liable to be condemned as filthy.

If the skin of the fruit does not enter into the food product, this feature is not of such moment, since the sand would be removed with the skins and discarded; but if the whole tomatoes or trimmings are used in the manufacture of a finished product it is very important that the washing be well done.

This is attempted by a great variety of methods, some of which are effective while others are worthless. Those washers in which the fruit is simply dipped into the water are practically useless. In some of these the water was changed so seldom that even if the soil were removed they would still be open to severe criticism. They may serve as scalders, but in no sense are they more than mere rinsers when it comes to the question of removal of dirt. Any washer which allows fruit to come through with soil still clinging to it is obviously ineffective.

After watching the operation of 10 or 12 different forms of washers and observing the fruit as it came from them, it appears that the most effective one seen was a machine devised, and in part constructed, as a homemade washer remodeled partly from a pea grader. It consists of a cylindrical body 8 feet long and 2 feet in diameter covered

with a screen of about 1-inch mesh wire. The cylinder rests on trunnions, so that there is no shaft or arm extending through the inside, and is made to revolve by a cogwheel gearing. The cylinder is so placed as to have a fall of about 1 foot between the ends. A water pipe furnished with small holes is suspended lengthwise somewhat above the center of the cylinder, so that as the fruit is rolled in the cylinder the water is sprayed over it. The tomatoes are fed in at the upper end and as the cylinder revolves they work along toward the lower end. The cylinder revolves about twenty times a minute and it takes about 30 seconds for the fruit to pass through, three or four crates being washed at the same time. This means that the fruit is rolled and tumbled a distance of about 60 feet, with fresh water sprayed over it for the whole distance, as the water when once used passes into the sewer.

One important point in favor of this arrangement is that there is sufficient rubbing of the tomatoes against each other to loosen and scour off the dirt, and when this has been done a comparatively small amount of water is required to wash it off. In some washers, even when a great pressure and a great amount of water were used to produce the spray, it was found that much of the dirt came through still clinging to the fruit. This difficulty seems to be due, not to the amount of water used, but to the fact that there is no effective means provided for rubbing the dirt loose. Another point in favor of the washer described is that the soft rot also is quite effectively removed, being pounded to pieces and carried through the screen with the waste water. The chief objection to this form of washer is that the very ripe fruit demanded by some canners and manufacturers would not survive such rough handling. That of course is an important point, but the question arises, Is it desirable to use such ripe fruit? And the fact remains that the effective removal of the dirt, if the skins are to go into the manufacturing process, is the most important point under consideration, and this or any other effective means by which the cleansing is actually accomplished would be acceptable.

PULPING.

The machinery used for pulping was practically the same in all factories. In a few plants the tomatoes or trimmings, as the case may be, were run through a chopper before going to the cyclone pulper. In some the stock was cooked before running it into the pulper, while in others the pulp was made from raw tomatoes. It makes little difference which method is used, so long as there is no material delay between the time of pulping and the using of the pulp. At some places the pulp is run as fast as made into a single vat and drawn out from the same during the day as needed. In this

way the fresh pulp is run in with some that may have been in the tank for several hours, and the fact that the tank is not completely emptied and cleaned out from morning till night allows spoilage to begin, and some injury to the product is done. A better way is to have a set of smaller vats, if the pulp is to be stored at all, so that each vat as it is emptied can be cleaned out before a new lot is run in, thus checking any fermentation that might result due to the storing of the pulp in the same vat throughout the day's run.

One serious criticism to be made of the gravity method of concentrating as practiced by some factories is the length of time that the product stands before being cooked up into the final product. This was found to vary in different factories from 30 minutes to half a day or more. A few did not leave a batch standing more than 30 minutes after the last of it had been run in, but by that time the first that had gone into the vat had usually been standing from one and one-half to two hours. Even this length of time allows a large number of organisms to develop, and it makes little or no difference in the final product where the decay occurs, whether in trimmings from the tables, in the vats after chopping (if that is practiced), or in the pulp in the vats before it is worked up. As soon as the fruit is peeled it is imperative that the trimmings should be worked up with the least delay possible, for it has been shown that spoilage takes place rapidly after the tomato tissues are torn.

Although this applies especially to the handling of trimmings, it is equally true of the whole tomato pulp. And furthermore, to expect that the results of carelessness in handling the pulp stock can be removed by subsequent cooking is a serious mistake, for though the product will be sterilized by sufficient cooking, the dead organisms that produced the decay remain in the ketchup, as well as some of their products of decomposition, and a marked deterioration in the character of the final product necessarily results.

CONCENTRATING.

The tomato pulp, as it comes from the pulper, contains the fibrous cellular material of the fruit, and also the " water " or, more properly, the juice of the tomato. The cellular material is insoluble in water and corresponds to the residue remaining after cider has been squeezed from apple pulp. In the juice or " water " are contained the most of those products which give to the tomato its characteristic taste and flavor. Among these are certain fruit acids and sugars without which the product has a flat taste.

The pulp obtained from the fruit in making ketchup is usually concentrated, by boiling or otherwise, to about 50 or 25 per cent of the original volume. Finely chopped tomatoes or tomato pulp on standing separates into two portions, due to small amounts of

gas held in the fibrous portions. The lower stratum contains a considerable proportion of the water from the fruit, together with some of the soluble solids, while the top contains more or less water and the insoluble portions, which consist largely of the cellular material. By careful manipulation it is possible to draw off half or two-thirds of the original volume in the lower layer, and some have supposed that they were removing nothing but the water by this operation, but the facts are quite to the contrary, as the water which is removed is as rich in the natural sugar and acid of the fruit and flavoring material as that remaining in the pulp.

A simple test of this loss can be made by placing some of the "water" in a suitable dish and boiling it down to about one-fourth of the original volume. The resulting product will be found to be especially rich in tomato flavor. Thus it is seen that the gravity method is an extremely wasteful one. Though this method of concentrating is cheaper than by boiling, this is about the only thing that can be said in its defense. Some claim that the product is subjected to heat for a shorter time by this treatment, and therefore it retains a better color; but with a proper arrangement of kettles having a good head of steam (80 pounds or more) the concentrating of the entire pulp to the consistency of ketchup can be accomplished in from 40 to 50 minutes, which is as short a time as is safe if even an approximately sterile product is to be obtained.

It was found that 9 per cent of the factories that were making ketchup from whole tomatoes were using the gravity method of concentrating. Of those that were making trimming pulp, 78 per cent used this method. Frequently manufacturers who make both whole tomato ketchup and also a trimming pulp grade use the entire juice method for the whole pulp and the gravity method on the trimming pulp.

At some plants it is customary to process the ketchup after bottling, while others find it unnecessary. The formula and amount of concentration are probably largely responsible for this difference, as well as for the varying temperatures at which the product is bottled.

STORING.

While some factories do not make up all of the pulp during the packing season many are doing this both because of the superior product obtained and because of the difficulty of keeping the stored pulp in good condition. Many of the canning factories simply make the pulp and sell it to the final manufacturer. The proper storing of the pulp is an important problem, since if it is not properly handled, spoilage will set in, offsetting any previous care which had been taken to produce a good product. The pulp is usually stored

in barrels, or in 5 or 6 gallon tin cans; stone jugs and jars or 1-gallon tin cans are also used, but to a much less extent. Manufacturers state that the use of the larger size tin cans is rapidly gaining in favor, while the barrel method is being discarded by the more progressive plants. The cost of these cans ranges at present from 24 to 70 cents each, and with care they can be used for from two to four years. From this it is seen that storing in cans is more expensive than in barrels, but a comparison of pulps put up by the two methods after a few months of storage is sufficient to demonstrate the superiority of the can method. The examinations made indicate that pulp stored in barrels always shows spoilage to a greater or less degree and possesses more or less of the following characteristics: Gas, sourness, excessive numbers of bacteria and yeasts, certain products of decomposition, and usually a change in color, flavor, and odor. However, in the use of the cheaper and consequently more lightly coated tin cans there is danger of exceeding the content of tin salts allowed in food products by Food Inspection Decision 126 (300 mg per kilo). The heavier coated and lacquered tins are, therefore, greatly to be preferred for this purpose as the tomato pulp is a product which, due to its acidity, has considerable action on the ordinary tin can.

In canning the pulp some plants make a practice of processing the cans after the product has been sealed. On the other hand, others say this is unnecessary if the product has been sufficiently concentrated by boiling and the cans filled while the pulp was boiling hot, direct from the kettles. When this is possible the labor and expense of processing is saved. In some factories the arrangement is such that the product from the kettles must pass quite a distance through pipes into the storage vat from which the cans are filled. This allows considerable cooling and contamination and will cause spoilage unless the cans are processed after sealing.

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